Review of Unit 4: Conservation of Momentum & Energy

- **Newton's Third Law:** When object 1 exerts a force on object 2, then object 2 exerts a force that is equal in magnitude but opposite in direction on object 1.

- **Momentum:** $p = mv$ (Unit: kg m/s)

- **Conservation of momentum:** The total momentum of a system is conserved as long as there is no external force acting on the system:

$$\boxed{\sum_i p_{i,before} = \sum_i p_{i,after}}$$

- Conservation of momentum is a direct result of Newton's Third Law.

Review of Unit 4: Conservation of Momentum & Energy

- **Work** done by force F on an object as it moves from x_1 to x_2 is defined as

$$W = \int_{x_1}^{x_2} F\,dx \qquad \text{(Unit: Joule = J)}$$

- **Kinetic energy** of an object is given by

$$K = \frac{1}{2}mv^2 \qquad \text{(Unit: Joule = J)}$$

- **Work-Energy Theorem:** Change in the kinetic energy of an object equals the total work done on the object

$$K_{after} - K_{after} = \int_{x_{before}}^{x_{after}} F_{net}\,dx \qquad \text{Or more simply, } \Delta K = W$$

Review of Unit 4: Conservation of Momentum & Energy

- If force F depends only on the position, then we can define **potential energy** as

$$U(x) = -\int_{reference}^{x} F\,dx \quad \Longleftrightarrow \quad F = -\frac{dU}{dx}$$

Force	Potential Energy
$F = \text{zero}$	$U = \text{constant}$
$F = \text{constant} = F_o$	$U = -F_o x$
$F = -kx$	$U = \frac{1}{2}kx^2$
$F = \frac{k}{r^2}$	$U = \frac{k}{r}$

Review of Unit 4: Conservation of Momentum & Energy

- The **total energy** of an object is

$$E = K + U$$

- If a system contains multiple objects, then the total energy of the system is

$$E_{total} = \sum_i E_i$$

sum over all the objects in the system

- **Conservation of Energy:** The total energy of a system is conserved if all the forces acting on the system depend only on the position.

$$\boxed{E_{before} = E_{after}}$$ if there is only one object

$$\boxed{\sum_i E_{i,before} = \sum_i E_{i,after}}$$ if there are multiple objects